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HIGH-RESOLUTION ATMOSPHERIC-TRANSMISSION SPECTRA FROM 5 TO 3 MI--ETC(U)
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from 5 to 8 μm

Kenneth M. Haught

Optical Radiation Branch
Optical Sciences Division

March 9, 1979

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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Approved for public release; distribution unlimited.

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Atmospheric transmittance
Fourier-transform spectroscopy
Infrared propagation
Molecular spectroscopy

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the field-measurement and data-reduction procedures used to obtain long-path, absolute-transmission spectra in the 5- to 3-μm atmospheric window. These measurements were carried out under a wide range of meteorological conditions. Key results of these measurements have been assembled into a data base of high-resolution atmospheric-transmission spectra which is now available on digital magnetic tape.

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S/N 0102-014-6601

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CONTENTS

HIGH-RESOLUTION ATMOSPHERIC-TRANSMISSION SPECTRA FROM 5 TO 3 μm

INTRODUCTION

In 1976 the Infrared Mobile Optical Radiation Laboratory (IMORL) facility of the Naval Research Laboratory obtained the first laser-calibrated, high-resolution field measurement of absolute transmission in the 5- to 3-μm atmospheric window [1]. Since that time, over fifty additional spectra have been acquired under a wide range of meteorological conditions during two separate field experiments. The key spectra from each field-measurement program have been assembled on digital magnetic tape. This report briefly summarizes the measurement process, reviews the data reduction procedures, and describes the companion data tape.

DESCRIPTION OF FIELD EXPERIMENTS

The high-resolution (0.08 cm^{-1}) measurements were made with a model 1001 Fourier-transform interferometer-spectrometer (FTS) system manufactured by the Carson-Alexiou Corporation, Newport Beach, California. A description of the FTS system and its installation aboard the IMORL receiver trailer appears elsewhere [2].

For use in the 5- to 3-μm atmospheric window, the interferometer was configured with an InSb detector and a CaF_2 beamsplitter. Radiation from a broadband infrared source in the IMORL transmitter trailer was projected across a 5-km path to the receiver trailer where it was collected, down-collimated, and directed into the interferometer. Interferograms of 8-cm optical retardation were sampled at 128 K (2^{17}) equally spaced points. (Interference fringes from the system's internal HeNe reference laser were used to control the sample spacing.) To minimize the effects of turbulence-induced signal degradation and to reduce noise levels in the computed spectra, from 50 to 100 interferometer scans were coadded prior to calculating the Fourier transform. Depending upon the number of scans coadded, sampling required from 10 to 20 min. Relevant atmospheric parameters were continously monitored to assure that the absorbing medium remained constant or changed sufficiently slowly during the averaging period.

At various intervals during the field experiments the receiver trailer was moved to the transmitter site to obtain "zero-path" calibration data. During these periods transmission spectra were recorded for the 50-m absorption path which separated the FTS system from the infrared source.

Two types of broadband infrared sources were available for sampling the atmospheric absorption spectra. A 1300-K graybody source was used initially, and it was found to

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perform satisfactorily in the 5- to 3-μm region. As the field measurements progressed, an 1800-K globar source was substituted in an effort to improve the FTS system's performance with a HgCdTe detector in the 12- to 8-μm spectral region. To simplify experimental procedures, the 1800-K globar source was then used with the InSb detector for the remainder of the absorption measurements made in the 5- to 3-μm atmospheric window. Since the appropriate zero-path calibration spectra were recorded with each type of source, and since the laser-extinction data were used to obtain a radiometric calibration for the long-path spectra, changing sources did not affect the radiometric accuracy of the resulting spectra.

In addition to measuring the broadband absorption, the FTS system was also used to record the emission spectrum of several DF and CO laser lines. The resulting emission spectra were later used to obtain improved wavenumber calibrations for the high-resolution atmospheric absorption spectra.

Related laser-extinction measurements made with the DF and CO lasers provided absolute-transmission normalizations for many of the high-resolution spectra. The laser-extinction measurement techniques required for making precision extinction measurements over long atmospheric paths had been developed during earlier field experiments in Florida [3] and California [4]. It is sufficient to note here that the laser measurement techniques center on the field-proven ability to project and subsequently collect the entire beam from a laser source and on the ability to maintain a high overall measurement accuracy (±2%) in related optical-system transmission measurements.

The laser extinction measurements used the same 90-cm diameter transmitter telescope to project a laser beam across the same 5-km path to the same 120-cm diameter receiver telescope used for the FTS measurements. During a typical day of field operation, the telescope useage would alternate between FTS measurements and laser-extinction measurements every hour or so. Spectra obtained in cases where the atmospheric conditions changed significantly have not been included on the data tape.

The Fourier transform of the 128-K-point interferograms was calculated on the FTS system's minicomputer by using the Carson-Alexiou-supplied software package. These transforms were phase corrected but not apodized.

To compensate for the wavenumber dependence of the transmission of the optical components and for the responsivity of the InSb detector, each 5-km-absorption-path spectrum was ratioed against a 50-m-absorption-path reference spectrum.

The wavenumber scale generated by the FTS system was based on the internal HeNe reference laser. Since the FTS system was operated in air, not vacuum, the dispersion of air between 0.63 and 4.0 μm limited the accuracy of the interferometer's wavenumber scale to about 0.1 cm^{-1}. Using the laser-extinction measurements to normalize the high-resolution spectra required that the location of each laser line in the atmospheric absorption spectra be established more closely than possible with the interferometer's internal wavenumber reference. Based on the sampled emission spectra of the DF and CO lasers, a simple least-squares wavenumber calibration was generated for the 5- to 3-μm region. These wavenumber assignments are also included on the accompanying data tape.

DATA ANALYSIS

A discussion of the techniques developed for the reduction and analysis of the laser-extinction data has been presented in an NRL Report [4], and the results for the 1977 IMORL field measurements are tabulated in an NRL Memorandum Report [5]. The techniques are summarized briefly here.

To normalize the FTS data, the amplitude of each ratioed absorption spectrum was measured at those spectral locations where DF or CO laser-extinction data were available. The ratio of the ratioed FTS amplitude to the observed absolute laser transmission was calculated for each laser measurement. These ratios were averaged to determine a normalization factor for each spectrum. (In general, less that a one- or two-percent variation with wavenumber would be seen over the spectral interval of the laser measurements.) Then each point in a ratioed absorption spectrum was multiplied by that spectrum's normalization factor to obtain the transmission-normalized spectrum. Figure 1 shows a plot of a high-resolution FTS spectrum to which an absolute-transmission normalization has been assigned.

DESCRIPTION OF THE DATA TAPE

Laser-calibrated, high-resolution spectra from the 1977 IMORL field experiments have been assembled onto a digital magnetic tape. This tape can be obtained from the National Technical Information Service (NTIS), Springfield, Virginia 22161. (NTIS accession number AD/A063683 should be specified to order a copy of the tape.)

The information contained on this 9-track, 800-bpi tape has been written in both the ASCII and EBCDIC character formats. The tape also contains index files (one for each character set) which provide descriptive information about the spectra and about the meteorological conditions under which the spectra were recorded. Each index file also carries a release number which identifies the specific version of the tape. To avoid potential ambiguities, it is recommended that users of the NRL-IMORL data base explicitly reference this release number when citing information from the tape.

Each logical record of the data file contains the following information: the number of the output point in the Fourier transform, an empirically assigned wavenumber based on laser-calibration spectra, a reference spectrum of DF- and CO-laser emission, and the measured transmission at that wavenumber for each of the long-path spectra. The data tape for the 1977 measurements contains 15 atmospheric-transmission spectra. Each spectra covers the region between approximately 1975 cm^{-1} and 3200 cm^{-1} with 20480 equally spaced intervals (approximately 0.0602 cm^{-1}).

A record layout of the FTS data tape is presented in Table 1. Figure 2 is a listing of the index file for the 1977 data tape, and Fig. 3 gives a listing of a 20-record segment of that tape. Figures 4 and 5 are facsimile copies of the Computer Products Catalog Data Sheet (NTIS-231) and the Computer Magnetic Tape File Properties Form (SF 277) which were submitted to NTIS with the 1977 data tape.

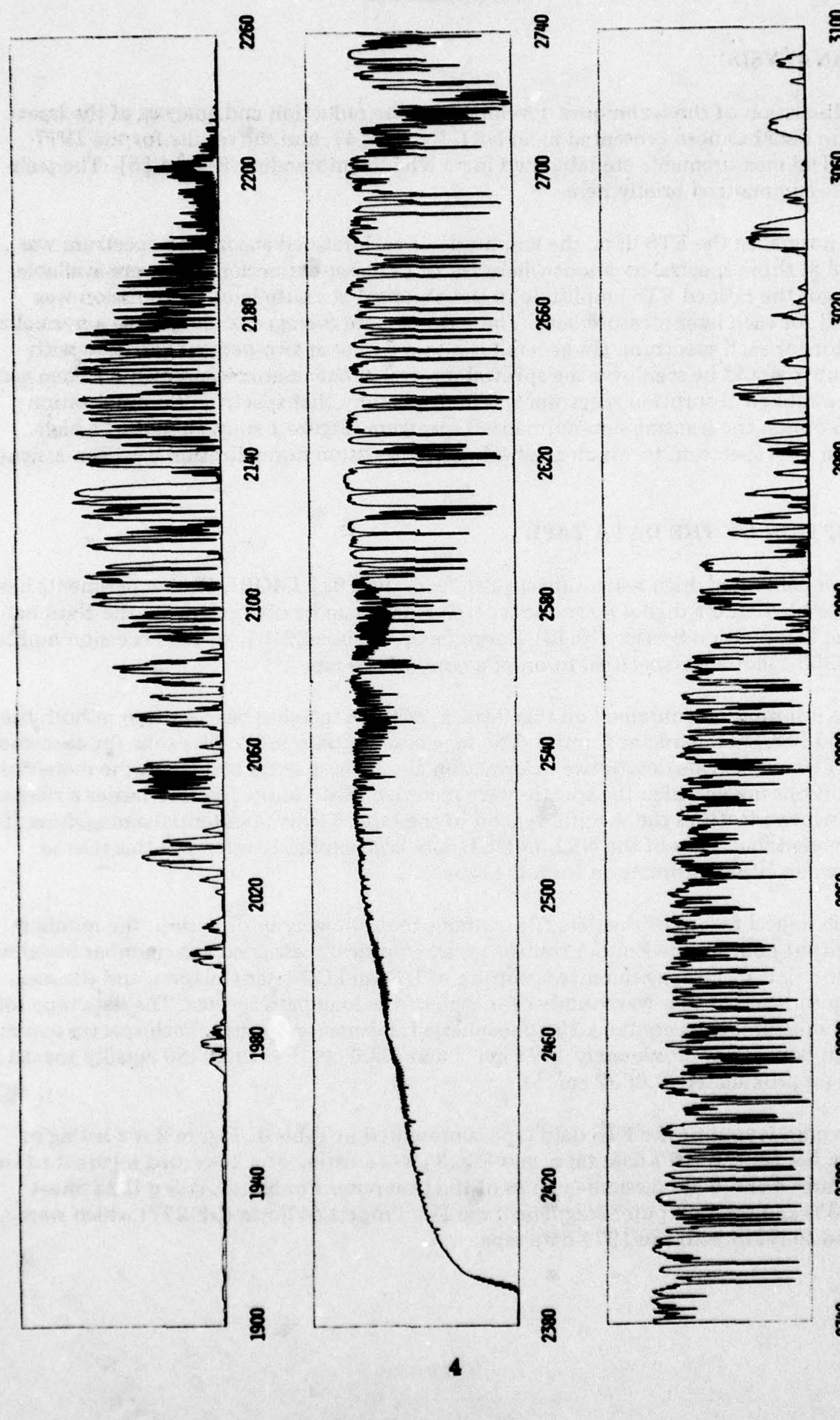

Fig. 1 — Spectrum 8024

Table 1 — Record Layout Form for NRL-IMORL Data Base

Field Name	Field Length	Field Description
LF*	1	ASCII line-feed character
NFFT	7	Output point of FFT
WAVENO	10	Empirical wavenumber (cm^{-1})
REF	8	Wavenumber reference spectrum
T(1)	5	Transmittance for spectrum 1
T(2)	5	Transmittance for spectrum 2
T(3)	5	Transmittance for spectrum 3
.	.	.
.	.	.
.	.	.
T(20)	5	Transmittance for spectrum 20
BLANK	3 (or 1)*	Blanks to pad record length to 128
CR*	1	ASCII carriage-return character

*The ASCII line-feed and carriage-return characters appear only with the ASCII version of the data base. For FORTRAN-language processing on PDP11 minicomputers under RT-11, these characters will be transparent to the user.

1977 NRL-IMORL DATA BASE

OPTICAL SCIENCES DIVISION,
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375

RELEASE DATE: 78 OCT 1
RELEASE NUMBER: 77-01

WHEN CITING MATERIAL FROM
THIS DATA COMPENDIUM, IT IS
REQUESTED THAT USERS IDENTIFY
THE SPECIFIC RELEASE NUMBER
OF THIS TAPE.

SPECTRUM NUMBER --->	03	119	120	121	144	145	147	148	153	154	157	158	159	160	161
YEAR	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
MONTH	03	03	03	04	05	05	05	05	05	05	05	05	05	05	05
DAY	03	31	31	01	20	20	21	21	23	23	24	24	24	25	25
TIME	1250	1215	1245	1310	1350	1415	1245	1300	1310	1330	1145	1210	1535	0955	1155
AIR TEMP (DEG C)--->	17.0	26.0	25.6	24.0	26.7	26.7	26.3	26.3	26.8	26.6	26.9	26.8	26.7	29.5	30.0
HUMIDITY (TORR) --->	13.2	16.0	18.0	17.7	14.7	14.8	16.3	16.5	17.4	17.4	20.3	20.0	21.0	20.0	20.5
AIR PRESS (MB) --->	1021	1022	1021	1019	1019	1019	1020	1020	1015	1015	1017	1017	1016	1015	1015
WIND SPEED (M/S)--->	3.1	2.2	3.0	3.7	6.2	3.3	4.4	4.4	2.3	2.6	3.4	3.7	5.9	2.6	3.7
WIND DIRECTION --->	92	100	155	100	90	82	108	108	118	113	124	123	118	247	150
SOLAR RAD (W/M2)--->	1.00	1.10	1.20	1.15	1.29	1.25	1.22	1.20	0.90	1.10	1.33	1.39	1.20	0.90	1.30
VISIBILITY (KM) --->	20	20	20	20	20	25	14	15	50	55	30	30	35	22	24
PATH LENGTH (KM)--->	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
PATH DIRECTION --->	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
OPERATOR --->	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH	KMH

***** READ THIS NOTICE ! *****

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CARE WERE EXERCISED WHILE
ASSEMBLING THE INFORMATION
PRESENTED IN THIS COMPENDIUM.

THE NAVAL RESEARCH LABORATORY
MAKES NO WARRANTY, EXPRESSED
OR IMPLIED, CONCERNING THE
ACCURACY OF THE DATA
CONTAINED HEREIN.

IT IS THE RESPONSIBILITY OF
THE INDIVIDUAL USER TO
DETERMINE THE SUITABILITY OF
THIS PRODUCT FOR SPECIFIC
APPLICATIONS.

Fig. 2 — Listing of the index file for the 1977 NRL-IMORL data base

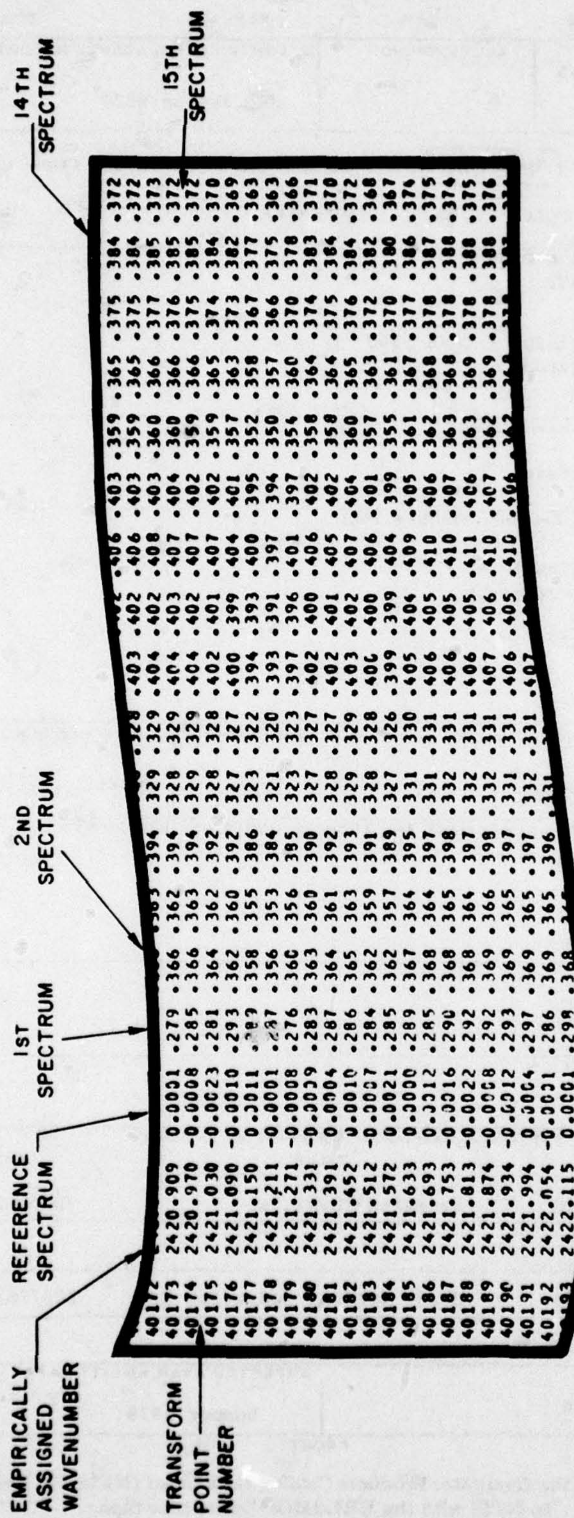

Fig. 3 — Listing of a portion of the 1977 NRL-IMORL data base

[ ] DELETE [x] NEW [ ] REPLACE [ ] CORRECTION

NTIS COMPUTER PRODUCTS CATALOG DATA SHEET	1. ACCESSION NO.	2. CONTRIBUTING AGENCY REPORT NO.	3. SUBJECT
		NRL Report 8297	

4. PRODUCT *(circle one)*

DATA FILE (circled) — PUBLICATION — DATA BASE REFERENCE SERVICE — SOFTWARE — MODEL, SIMULATION

5. AGENCY, BUREAU, DIVISION, AND ADDRESS

DEPARTMENT OF THE NAVY

Optical Sciences Division - Code 5560
Naval Research Laboratory
Washington, DC 20375

6. PRODUCT NAME *(Use agency nomenclature)*

1977 NRL-IMORL Data Base

7. DESCRIPTORS OF PRODUCT *(Keywords, identifiers, etc.)*

ATMOSPHERIC TRANSMITTANCE
Fourier-Transform Spectroscopy
Infrared Propagation
Molecular Spectroscopy

8. DATES OF COVERAGE *(For one-time reports, use as-of-date, for software, use date and release no.)*

Release date: 78 OCT 1
Release number: 77-01

9. FILE SIZE IN NO. OF:

REELS 1 PUNCHED CARDS

10. AVAILABILITY STATEMENT - AGENCY NAME AND ADDRESS, ORDER NO., ETC. *(If NTIS sells, leave blank)*

11. PRICE INFORMATION

12. GEOGRAPHIC SCOPE

13. TECHNICAL REPRESENTATIVES *(List at least one for subject and one for media)*

NAME	TITLE	PHONE NO.
HAUGHT, Dr. Kenneth M.	Research Physicist	202/767-3005
ULRICH, Dr. Peter B.	Head, Optical Radiation Br.	202/767-3068

14. DOCUMENTATION

[ ] AVAILABLE

EXPECTED AVAILABILITY DATE

Summer 1979

FORM NTIS-231 (REV. 6-74) FRONT USCOMM-DC 9411-P74

Fig. 4 — Facsimile copy of the Computer Products Catalog Data Sheet (NTIS-231) which was submitted to NTIS with the NRL-IMORL data-base tape

NTIS COMPUTER PRODUCTS CATALOG DATA SHEET

15. COMPUTER PRODUCT ABSTRACT

In 1977 the Infrared Mobile Optical Radiation Laboratory (IMORL) facility of NRL's Optical Sciences Division conducted in-situ field experiments which precisely measured infrared transmittance along a 5-km coastal path at the Cape Canaveral Air Force Station in Florida. Fourier-transform spectroscopy (FTS) instrumentation capable of resolving the vibration-rotation absorption-line structure of atmospheric gases was used to record the infrared absorption of the experimental path during a variety of meteorological conditions. Related laser-extinction measurements made along the same path provided absolute-transmission normalizations for the FTS spectra. Fifteen of these normalized spectra and a tabulation of associated meteorological measurements have been assembled on digital magnetic tape. The resulting 1977 NRL-IMORL Data Base provides a unique compendium of spectral information about the coastal atmosphere and its infrared properties.

16. DATA FILE TECHNICAL DESCRIPTION

Data File produced on;

Digital Equipment Corp. (cpu mfr.) PDP11/40 (model) RT-11 (V02B-05) (operating system)

File is physically coded in: 9 (tracks) / 800 (density) / ASCII (and EBCDIC) (character code)

Also available in: ______ (tracks) / ______ (density) / ______ (character code)

17. SOFTWARE TECHNICAL DESCRIPTION

Software is written in;

Fortran ____ COBOL ____ Basic ____ Assembly ____ Other (Specify) ______

Software requires;

CPR Mfr. ______ Model(s) ______ Operating system(s) ______

Minimum of ______ K bytes core. The following special features and/or additional requirements in hardware:

______

SIGNATURE OF AGENCY REPRESENTATIVE, PHONE NO., AND DATE	SIGNATURE OF NTIS REPRESENTATIVE AND DATE FORM PREPARED

FORM NTIS-231 (REV. 6-74) BACK USCOMM-DC 8411-P74

Fig. 4 — Facsimile copy of the Computer Products Catalog Data Sheet (NTIS-231) which was submitted to NTIS with the NRL-IMORL data-base tape

COMPUTER MAGNETIC TAPE FILE PROPERTIES

01. Completion Date (Year / Month / Day)	02. Form Prepared By (Name and Phone)	03. Reel ID Number (Property Control No.)
78 / 12 / 26	Kenneth M. Haught 202/767-3005	

04. Recording Date (Year / Month / Day)	05. File Identifier or Descriptive Title	06. Short Title (External Label Name)
78 / 10 / 01	1977 NRL-IMORL Data Base	NRL77

07. Source Unavailable (Year / Month / Day)	08. Documentation (Yes / No) Available (Enter Citation)	09. File Position on Reel
79 / 06 / 30	Yes: x — NRL Report 8297	___ of 23

10. To Be Returned (Yes / No / To Other Than The Sender)	11. Submitting Organization & Address	12. Receiving Organization & Address
No: x	Optical Sciences Division - Code 5560 Naval Research Laboratory Washington, DC 20375	

13. Due Back Date (Year / Month / Day)

14. Technical Contact(s) & Phone Number(s)

Kenneth M. Haught 202/767-3005

Peter B. Ulrich 202/767-3068

RECORDING SYSTEM CHARACTERISTICS

EQUIPMENT MANUFACTURER AND MODEL		17. No. of Tracks (7 / 9 / Other)	18. Parity (Odd / Even)	19. Density (BPI)
15. Processing Unit	Digital Equipment Corporation PDP11/40	9: x	Odd: x	800
16. Tape Subsystem	Digi-Data 1730			

RECORDING SOFTWARE		22. Internal File Identifier
20. Operating System, Release & Version	RT-11 (V02B-05)	NRL77w.xxx (w=A,E xxx=000, 033-052)
21. Utility Program or Data Base Language	PIP	

23. Characters Set (Graphics): [X] ASCII [ ] BCD [ ] Other (Specify) [X] EBCDIC [ ] FIELDATA [ ] Non-Print Codes

24. Recorded Label (Internal Label): [X] Header [X] ANSI X 3.27 Standard [ ] Other [X] Trailer [ ] FIPS Standard [ ] None

FILE CHARACTERISTICS

NUMBER OF RECORDS		27. Record Type	28. Records/Block (Blocking Factor)	TYPE OF FILE ORGANIZATION (Check One Box)
25. Physical	See 33	[X] Fixed Length	4	[ ] One File One Reel
26. Logical		[ ] Other Than Fixed		[ ] One File Multiple Reels

RECORD LENGTH					
30. Physical	512	[X] Bytes	[ ] Chars.	[ ] Words (Bits/Word)	[X] Multiple Files One Reel
31. Logical	128	[X] Bytes	[ ] Chars.	[ ] Words (Bits/Word)	[ ] Multiple Files Multiple Reels

SUPPLEMENTAL INFORMATION

32. Use/Handling Constraints (Specify if Yes): Yes / No: x

33. For Submitting Organization Use This tape contains 23 ANSI-labeled files (69 physical files). Files 1 and 3 contain 16 records, file 2 has 5120 and files 4-23 each contain 256 records. The first two files contain the EBCDIC version of the data base, while the ASCII version comprises the remaining 21 files.

All tape labels are written in the ASCII character set.

277-101 INSTRUCTIONS ON OTHER SIDE Standard Form 277 (12-77) U.S. Dept. of Commerce-NBS FIPS Pub. 53

Fig. 5 — Facsimile copy of the Computer Magnetic Tape File Properties Form (SF 277) which was submitted to NTIS with the NRL-IMORL data-base tape

RECOMMENDATIONS FOR ACCESSING DATA FROM THE TAPE

The EBCDIC-coded information of the FTS data tape precedes an ASCII-coded version of the same information. The EBCDIC-character version of the data base consists of the index file and a single data set containing 20480 spectral records. The EBCDIC index file (which is the second physical file on the tape) is bracketed by ANSI-type VOL1 and EOF1 tape labels which are compatible with the RT-11 operating system used on PDP11 minicomputers. Similarly, the EBCDIC spectral data file (which is the fifth physical file on the tape) is bracketed by HDR1 and EOF1 tape labels.

Following the two EBCDIC-character data sets (which represent six physical files) are 21 data sets written with ASCII characters. Like the EBCDIC data files, each ASCII file is bracketed by HDR1 and EOF1 tape labels. Thus, when the data tape is processed as a labeled tape, each HDR1-data-EOF1 triplet will be treated by the operating system as a single file.

The first ASCII data set (which is the eighth file on the tape) is simply an ASCII version of the index file. The 20480 records of spectral data are divided into 20 data sets of 1024 records each, which follow the ASCII index file.

PROCESSING THE NRL-IMORL DATA-BASE TAPE

This section of the report describes procedures which can be used to process the data tape on different series of computers.

PDP11 Computers

The ASCII-character version of the data base is fully compatible with the RT-11 operating system available on PDP11-series minicomputers manufactured by the Digital Equipment Corporation. The RT-11 name and extension of the ASCII version of the index file is NRL77A.IDX. The 20 files containing the ASCII version of the spectral data are named NRL77A.033 through NRL77A.052 and contain the 33rd through 52nd 1024-point portions of the output from a 128-K-point Fourier transform. Both the index file and the spectral data may be accessed directly from magnetic tape under RT-11, though some applications would benefit from copying segments of the tape to other storage media. The RT-11 peripheral interchange program (PIP) and the text editor (EDIT) can be used for these purposes.

To obtain a listing of the index file, the user should type:

```
.RUN PIP
*LP:=MT0:NRL77A.IDX
```

When data are processed from this tape with FORTRAN-language programs, the CALL ASSIGN subroutine (available from the RT-11 FORTRAN library) can be used to assign the data file to a specific FORTRAN logical I/O unit number.

ASC Computers

The EBCDIC version of the data base is appropriate for use on the ASC-series computers manufactured by Texas Instruments Corporation. To obtain a listing of the index file, the following Job Specification Language (JSL) statements are suggested:

```
/     FD       FT03F001,RCFM=FB,BKSZ=512,LREC=128
/     FIT      FT03F001,DEN=800,LABL=2/NL,EFID=xxxxxx
/     FOSYS    FT03F001
```

where xxxxxx is the installation-assigned external-file-identification parameter for the data tape. The EBCDIC version of the spectral data contains 5120 blocks (with 512 bytes per block). When using an FIT statement to transfer this file to disk storage, the BAND parameter in the file definition statement should be used to ensure that enough disk storage will be available. For accessing the spectral data on a FORTRAN logical I/O unit (say unit 4), the following JSL is suggested:

```
/    FD       FT04F001,RCFM=FB,BKSZ=512,LREC=128,BAND=10/100/10
/    FIT      FT04F001,DEN=800,LABL=5/NL,EFID=xxxxxx
```

If both the index file and the data file are to be processed in the same job, use of the multiple file request statements (MFR and MFRE) will improve job turnaround time.

IBM System/370 Computers

The EBCDIC version of the data base is also compatible with the System/370-series computers manufactured by International Business Machines Corporation. Under the OS/370 operating system, the following data definition (DD) statements of the Job Control Language (JCL) are suggested:

```
//FT03F001   DD   LABEL=(2,BLP),DISP=OLD,
                  DCB=(DEN=2,RECFM=FB,BLKSIZE=512,LRECL=128),
                  UNIT=yyyyyy,VOL=SER=zzzzzzzz
//FT04F001   DD   LABEL=(5,BLP),DISP=OLD,
                  DCB=(DEN=2,RECFM=FB,BLKSIZE=512,LRECL=128),
                  UNIT=yyyyyy,VOL=SER=zzzzzzzz
```

where zzzzzzzz is an installation-assigned volume serial number which identifies the data tape and yyyyyy is an installation-dependent parameter which specifies a 9-track magnetic-tape drive capable of processing 800-bpi tapes (such as UNIT=TAPE9 or UNIT=2400). In the above example, the index file would be associated with the file FT03F001 and the spectral data file with the file FT04F001. These files correspond to logical I/O units 3 and 4 in FORTRAN-language user-written programs.

CYBER and 6600-Series Computers

Either the ASCII or EBCDIC character-set version of the data base may be used with equipment manufactured by the Control Data Corporation: CDC 6400, 6500, and 6600

and CYBER170-series and CYBER70-series computers. Under the NOS operating system, the following procedure file associates the EBCDIC version of the index file with logical unit 3, and the spectral data file with logical unit 4, of a previously compiled FORTRAN program:

```
FILE,TAPE3,RT=F,BT=K,RB=4,FL=128,MBL=512,CM=YES.
FILE,TAPE4,RT=F,BT=K,RB=4,FL=128,MBL=512,CM=YES.
REQUEST,TAPE1,NT,D=800,F=S,CV=EB,LB=KU,VSN=wwwwww.
SKIPF,TAPE1,1,C.
COPYBF,TAPE1,TAPE3,1,C.
SKIPF,TAPE1,TAPE4,1,C.
COPYBR,TAPE1,TAPE4,1,C.
RETURN,TAPE1.
REWIND,TAPE3,TAPE4.
LDSET,FILES=TAPE3/TAPE4.
LGO.
```

where wwwwww is the installation-assigned volume-serial-number and the compiled FORTRAN program resides on a file named LGO.

ACKNOWLEDGMENTS

The author would like to acknowledge the contributions of the members of the IMORL team who participated in the 1976 and 1977 field measurements. J.A. Curcio provided the telepyrometric visibility measurements and D.H. Garcia was responsible for the acquisition of the supporting meteorological data presented in the index file of the data tape. J.A. Dowling, C.O. Gott, S.T. Hanley, and R.F. Horton carried out the laser-extinction measurements, many of which were used to obtain the absolute-transmission normalizations for the spectra presented on the tapes.

This work was sponsored by PM22/PMS405 of the Naval Sea Systems Command, Washington, D.C. 20362.

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